Kentucky Geological Survey
UNIVERSITY OF KENTUCKY

Kentucky Geology

Earth Resources—Our Common Wealth

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Our mission is to increase knowledge and understanding of the mineral, energy, and water resources, geologic hazards, and geology of Kentucky for the benefit of the Commonwealth and Nation.

In this issue

Helping the Commonwealth adopt a new seismic design standard for residential buildings

Three of the most powerful earthquakes in U.S. history, all approximately magnitude 7.5, followed by thousands of aftershocks, occurred during the winter of 1811–1812 in the New Madrid Seismic Zone. The effects of the earthquakes were catastrophic. If an earthquake of similar magnitude occurred today, buildings in western Kentucky could be severely damaged and some damage could also occur in central Kentucky. The January 26, 2001, earthquake in India (magnitude 7.6), which was similar to the 1811–1812 New Madrid events, caused 19,727 deaths and 166,000 injuries. The India earthquake destroyed 348,000 houses and damaged 844,000 houses. The earthquake that occurred in 1980 in Sharpsburg, in northeastern Kentucky, caused damage to many buildings even though it was a moderate earthquake (magnitude 5.2).

When earthquakes occur in countries that do not have adequate seismic design for buildings, the result can be a tragic loss of lives and costly loss of property. For example, the August 17, 1999, earthquake in Turkey (magnitude 7.4) caused 17,118 deaths and more than 50,000 injuries. In California, which has the best seismic design provisions in building codes, which are strictly enforced, the 1989 Loma Prieta earthquake (magnitude 7.1) caused only 63 deaths, and the 1994 Northridge earthquake (magnitude 6.8) caused only 61 deaths, even though both earthquakes occurred in highly urbanized areas.

The location of the New Madrid Seismic Zone.

(Continued on page 3)

Earth science outreach

Rocks and hearts

Patrick Gooding, Ray Daniel, and Mark Eversole taught earth science outreach workshops to small groups of adults with disabilities on January 30, February 6, and March 6. The Christian Appalachian Project provides a 1-week respite for care providers (parents and guardians), by offering programs such as these for adults with disabilities. The KGS program began with the participants gathering rocks and geodes from outcrops in Estill County. The samples they collected were brought to the KGS Well Sample and Core Library, where Patrick, Ray, and Mark identified the rocks. The participants were then taught how to cut and polish the rocks. Patrick, the manager of the Well Sample and Core Library, discussed an exhibit of fossils and minerals and presented a slide show to explain interesting facts about geology. Patrick has done volunteer work for persons with disabilities since he was a teen-ager. The response from the participants has been enthusiastic and positive. It has been a heart-warming experience for everyone involved. For more information, please contact Patrick at 859.389.8810 or by e-mail at gooding@kgs.mm.uky.edu. ❖

Director's Desk

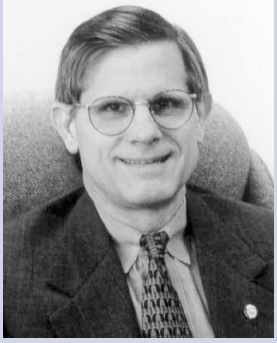
The combined meeting of the Southeastern and North-Central Sections of the Geological Society of America was held in Lexington April 3–5. People from KGS, the University of Kentucky, and the University of Cincinnati organized the meeting. Planning began 5 years ago, and hundreds of work hours were contributed by scores of people. John Kiefer and Dave Harris deserve much of the credit for the success of the meeting: Dave organized the technical program and John conducted the business affairs with GSA staff in Boulder, Colo. Thank you both for your great efforts!

Many others worked above and beyond their normal duties. Frank Ettensohn, Sue Rimmer, Tom Lowell, Cindy Carney, Steve Greb, Steve Cordiviola, Doug Reynolds, Geaunita Caylor, Sue Manley, Drew Andrews, Jim Drahovzal, Ann Watson, Dave Moecher, Tammi Johnson, Jackie Silvers, Mandy Long, Meg Smath, Richard Smath, Bart Davidson, Pam Stevens, Pat Gooding, Ray Daniel, Mark Eversole, Andrea Mitchell, Carol Ruthven, and Collie Rulo did essential jobs that made the meeting possible. I also want to recognize the people who organized and chaired sessions.

Approximately 1,200 people attended. A total of 586 papers were featured in eight concurrent oral sessions and five poster sessions. There were six workshops, 10 field trips, 14 special events, and a full guest program. The exhibition hall had 40 exhibitors.

KGS geologists gave 26 papers, presided over five symposia, hosted one workshop, and led three field trips. I am proud that so many papers were accepted and that KGS staff contributed their scientific expertise.

The benefits from a meeting such as this to the geoscience professionals, researchers, teachers, students, and the community are many. It is important for scientists to get together to share ideas and debate interpretations. Such meetings are where new ideas and methods are tested in a "court of peer opinion" before they are presented in journals, books, popular media, and in some cases, public policy. This is how science advances. ❖



James C. Cobb

Technology Transfer

On May 16, in Lexington, **Brandon Nuttall** will conduct a 1-day workshop, "Integrating GPS and GIS for the Petroleum Industry." This workshop, designed for oil and gas professionals and field personnel, will explain how to integrate global positioning system (GPS) data and geographic information systems (GIS) mapping applications. For more information, contact Brandon at 859.257.5500 or by e-mail at bnuttall@kgs.mm.uky.edu.

On June 4, in Lexington, **Dave Harris** will conduct a 1-day core workshop and field trip, "Outcrop Analogs for Trenton/Black River Fractured Dolomite Reservoirs." The workshop is sponsored by the Petroleum Technology Transfer Council (PTTC), Appalachian Region. The morning workshop will be at the KGS Well Sample and Core Library, and the afternoon field trip will be in Clark County. This workshop and field trip will be of interest to energy industry geologists and geophysicists working in Ordovician hydrocarbon plays in the Appalachian, Michigan, and Illinois Basins. The Ordovician outcrops and cores will provide a unique glimpse of fault-controlled dolomitization, a process that has resulted in the formation of prolific oil and gas reservoirs elsewhere in the Appalachian Basin in New York, Ontario, Michigan, Ohio, and Kentucky. For more information, contact Dave at 859.257.5500 or by e-mail at harris@kgs.mm.uky.edu.

Information about both workshops is available at the PTTC Appalachian Basin Web site, at karl.nrcce.wvu.edu/workshops.html. ❖

Land-Use Planning and Geologic Maps

Continued growth in Kentucky requires a better understanding of the physical environment. Taxpayers bear the cost of poor development decisions that result from inadequate technical input. KGS is cooperating with the U.S. Department of Agriculture–Natural Resources Conservation Service to produce land-use planning maps based on geologic and environmental analyses. These maps will be produced for counties (1:48,000 scale) and 7.5-minute quadrangles (1:24,000 scale). They provide an interpretation of the local geology in nontechnical language, and can be used by homeowners, developers, and planners.

The maps provide information on how the underlying rock in an area affects excavation and foundations, on-site wastewater treatment systems, residential and industrial developments, highway and street development, and pond and reservoir construction. Photographs of sites in the area illustrate the geologic discussion.

Preliminary maps are available for review and comment for the Berea 7.5-minute quadrangle and Fayette, Jessamine, Scott, and Woodford Counties. For more information, please contact **Dan Carey** at carey@kgs.mm.uky.edu or call 859.257.5500. ❖

Karst Landscape—Astonishing Beauty and Hidden Hazards

Carol L. Ruthven and James C. Currens
April 2002

What is karst?

Fifty-five percent of the state of Kentucky has landscape characterized by karst, yet the term "karst" is unfamiliar to many people outside of the community of geoscientists. The *Glossary of Geology*[1] defines karst as "A type of topography that is formed on limestone, gypsum, and other rocks, primarily by dissolution, and that is characterized by sinkholes, caves, and underground drainage." The term is derived from a Slavic word that literally means "barren, stony ground." It is also the name of a region in Slovenia near the border with Italy that is well known for its sinkholes and springs. In Kentucky, limestone and dolostone rock units are susceptible to developing karst topography, which has formed over hundreds of thousands of years.

Distinctive karst landscape in Kentucky

Much of the scenic beauty in the state is related to karst. Kentucky is one of the most famous karst areas in the world. Mammoth Cave in western Kentucky is the longest surveyed cave in the world, with more than 350 miles of passages. Another cave system in the same region is over 100 miles in surveyed length. Two other caves in the state stretch more than 30 miles, and nine Kentucky caves are among the 50 longest caves in the United States. Karst landscape is one of the reasons why the world-famous thoroughbred horse industry is located in the Inner Bluegrass. The combination of fertile soil and spring water containing dissolved calcium and phosphate from the limestone rock contributes to a unique environment for strong bone growth in horses. Much of the rich agricultural land that supports the historically distinctive Kentucky burley tobacco and bourbon industries, and a substantial amount of the Daniel Boone National Forest, are underlain by karst.

Hidden hazards of karst landscape

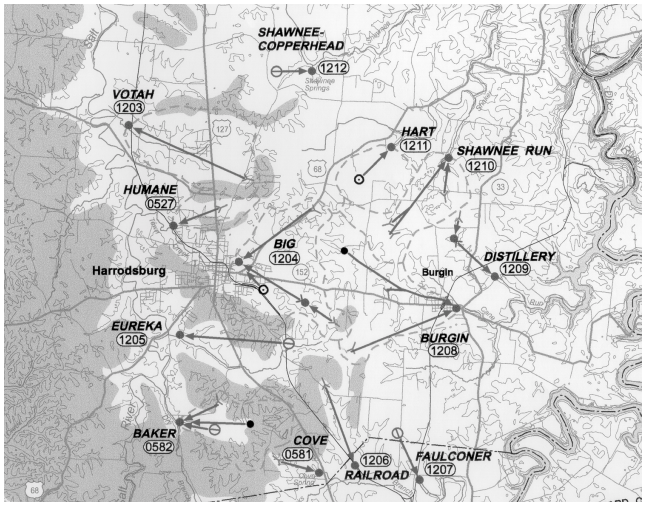
The same landscape, while offering economic and recreational opportunities, can pose geologic hazards. As water moves underground, from hilltops toward streams through tiny fractures in limestone bedrock, limestone and dolostone rock is slowly dissolved away by weak acids found naturally in rain and soil water. This dissolution of rock can create different karst hazards, including sinkhole flooding, sudden cover collapse, collapse of lagoons resulting in waste spills, and infiltration of radon gas. The economic losses of karst hazards are largely hidden because they are distributed across the state, and although frequent, they typically affect small numbers of people in each incident. The economic costs are often indirect. They are absorbed by local government, and reflected in higher taxes required to repair roads and extend public water lines to serve communities whose groundwater supplies from karst aquifers have been polluted.

Sinkhole flooding—A sinkhole is an internally drained depression in a karst area. Its shape is circular, and it is bowl-shaped in cross section. Water drains to the subsurface through the soil and cracks in the bedrock that have been enlarged. Flooding can result when the outlets of sinkholes are clogged by the accumulation of trash, or when the water table rises. This will inevitably cause flooding, either at the site of the sinkhole or at another sinkhole somewhere along the flow path. Researchers at KGS are compiling data about sinkhole collapses. A sinkhole collapse occurs when soil collapses into an underlying crack that has been enlarged as water dissolves limestone. If you know where and when a sinkhole collapse occurred, you can fill out a reporting form on the KGS Web site at www.uky.edu/KGS/announce. If enough data are obtained, KGS will develop maps showing the probability that a sinkhole will form. The maps will show the average number of cover-collapse sinkholes that will form in a unit area within a specified period of time (for example, two sinkholes a year per square mile).

Radon gas—Radon is considered one of the causes of lung cancer. When constructing homes and other buildings in central Kentucky, keep radon in mind. The Tanglewood Member of the Lexington Limestone, and other geologic units, can pose a problem if proper precautions are not taken. The phosphate minerals in the limestone contain traces of uranium, which releases radon when it decays. Radon can accumulate in karst cavities underneath a home, and rise up into the home as a result of changes in atmospheric pressure. If homes or other buildings are built on the Tanglewood Limestone Member, care should be

One of the hidden karst hazards: this highway near Bowling Green caved in as a result of sudden cover collapse.

[1]Jackson, J.A., 1997, Glossary of geology [4th ed.]: American Geological Institute, 769 p.



Part of the 1:100,000-scale karst groundwater basin map for the Harrodsburg 30 x 60 minute quadrangle.

taken to make sure that the buildings, basements in particular, are well ventilated so that radon gas will not accumulate.

The expertise of hydrogeologists at KGS, along with topographic and other maps published by KGS, are resources available to the public to identify geologic hazards, and mitigate the risks associated with those hazards.

Karst and protecting groundwater quality

Pollution of groundwater has become an environmental concern, particularly for rural landowners, because groundwater supplies a large percentage of rural drinking water and water for agricultural use. One-quarter of Kentucky's population depends on groundwater for its drinking-water supply. Information from geologic maps can be used to identify areas that may be susceptible to groundwater contamination. This is particularly important in areas with karst. Contaminants or pollutants such as pesticides, fertilizers, animal waste, waste leaking from landfills and septic tanks, runoff from parking lots in urban areas, or chemical spills from vehicle accidents drain in passageways below the surface with little filtration or chemical changes.

Much of the groundwater in Kentucky is stored in karst aquifers. To promote greater awareness of the need for environmental protection of this valuable resource, KGS has published a color poster, "Protect Kentucky's Karst Aquifers from Nonpoint-Source Pollution," by Jim Currens. The poster defines karst aquifers and nonpoint-source pollution, explains how karst aquifers become polluted, and outlines suggestions for protecting karst aquifers. This information will be of interest to environmentalists, naturalists, teachers and students, and the general public. The poster is available free at the KGS Publication Sales office on the University of Kentucky campus; copies are also available by mail for the cost of shipping and handling.

Hydrogeologists use groundwater dye-trace experiments to determine the general direction of groundwater movement in karst areas and identify the location, size, and shape of watersheds draining to specific springs. In these experiments, environmentally safe dyes are poured into a spring or sinking stream (a small stream that disappears underground). Packets of material that absorb the dye are attached to anchors and placed in springs at which the dye might reappear.

The results of dye-trace experiments allow hydrogeologists to map groundwater flow paths. This information is used to determine the locations of karst groundwater basins, which are plotted on 30 x 60 minute quadrangle maps (1:100,000 scale). These maps, published by KGS, can be used by emergency-response personnel to minimize the damage to karst aquifers and drinking-water supplies, if hazardous-waste spills or other accidents introduce contaminants into a groundwater system.

Karst groundwater basin maps are available for the Beaver Dam, Bowling Green, Campbellsville, Harrodsburg, Lexington, and Somerset 30 x 60 minute quadrangles. In a forthcoming publication, *Kentucky Is Karst Country,* author Jim Currens discusses, in nontechnical language, karst landscape, sinkholes, springs, and geologic hazards, and offers advice for protecting karst groundwater resources.

The karst groundwater basin maps and other relevant publications are available online at www.uky.edu/KGS/pubs/lop.htm. From this site, a map or publication can be downloaded as a PDF file and viewed using Acrobat Reader (available free online from Adobe). To order a publication, please contact the Publication Sales office at 859.257.3896 or call toll free 1.877.778.7827.

For more information about the karst research program at the Kentucky Geological Survey, contact Jim Currens at 257-5500 or by e-mail at currens@kgs.mm.uky.edu. ❖

Nontoxic, colored dyes are added to springs to trace the flow paths of groundwater. Dark area in water is dye.

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***(Seismic,** continued from page 1)*

A key question in designing building codes and considering seismic risk is "What level of risk is acceptable at what cost in building design?" Building design must take into consideration factors related to the geology/seismology, engineering, economics, and safety. The 2002 Kentucky Residential Code (KRC) was adopted from the 2000 International Residential Code (IRC), with a significant amendment to the seismic design provision. The 2002 KRC was to take effect on September 7, 2001, and be enforced on a mandatory basis beginning January 1, 2002. The mandatory enforcement was delayed because of concerns expressed by the Structural Engineers Association of Kentucky about the amendment to the seismic design provision. An ad hoc committee was formed by the Department of Housing, Building, and Construction to review this issue and to make a recommendation. Dr. Zhenming Wang of KGS served on the committee.

Dr. Wang presented KGS's recommendations, developed by a group of experts from KGS, the Department of Geological Sciences, and the Department of Civil Engineering at the University of Kentucky, to the committee. One of KGS's recommendations was to develop seismic design categories based on a ground-motion hazard with a 5 percent probability of occurring within the next 50 years for western Kentucky. The committee accepted the recommendation and revised the seismic design provision of 2002 KRC. The new seismic design standard was adopted by the Board of Housing, Buildings, and Construction on February 14, 2002.

KGS is striving to serve the Commonwealth of Kentucky through scientific research, technical assistance, and public education. For more information on earthquakes, contact Zhenming Wang at zwang@kgs.mm.uky.edu or call 859.257.5500.❖

Field notes from across Kentucky

Nitrate in Groundwater—Finding the Source of the Contaminant

Ongoing research conducted by the Water Resources Section is shedding light on localized, elevated nitrate-nitrogen concentrations in western Kentucky. Current agricultural practices have been the suspected source of elevated nitrate in shallow groundwater systems (< 100 feet below land surface), but that is not the case at one location in Henderson County.

A farmer's domestic water supply has consistently contained nitrate-nitrogen greater than 40 mg/L since sampling began in 1996. The maximum contaminant level set by the U.S. Environmental Protection Agency is 10 mg/L. Groundwater samples collected from monitoring wells located in active row crop settings and a shallow sandstone aquifer have not contained nitrate-nitrogen concentrations greater than 15 mg/L, which is about four times lower than the domestic water-supply concentration. This rules out current agricultural practices as being the source of elevated nitrate-nitrogen in the farmer's domestic supply well.

The source of elevated nitrate-nitrogen is actually organic matter associated with an abandoned dairy feeding lot, which has been out of operation for approximately 25 years. Soil cores were collected to determine the aerial extent of the organic matter and movement of nitrate-nitrogen through the soil column. From these soil cores a remediation plan was designed, which we hope will remove the major source of nitrate at this location. Five hundred eighteen cubic yards of organic-rich soil was removed and spread on a nearby pasture field. The excavated area was backfilled with native soil and leveled to the original surface grade.

The plan is to sample monitoring wells and collect soil cores over the next 3 years to determine if nitrate-nitrogen concentrations begin to decrease within the soil column and shallow sandstone aquifer. For more information, contact **Glynn Beck** at ebeck@kgs.mm.uky.edu or at 270.827.3414. ❖

Spotlight on new publications

"Coal Availability in Western Kentucky," by Gerald A. Weisenfluh, William M. Andrews Jr., Robert E. Andrews, and John K. Hiett

Factors affecting the development of coal resources in the Western Kentucky Coal Field include distribution of coal resources, historical mining in the region, and restrictions that impede the development of remaining resources. Tonnage estimates of remaining resources for future planning are provided for the region and detailed study areas.

Water Well and Spring Location Maps, by Bart Davidson

Four maps at a scale of 1:100,000 show the distribution of water wells, springs, and groundwater dye-trace locations for the Lexington, Harrodsburg, Somerset, and Bowling Green 30 x 60 minute quadrangles. Each map displays four types of wells: domestic (or private), industrial, public, and monitoring. The dye-trace locations indicate areas where scientists have attempted to determine the direction that groundwater flows beneath the surface. These maps will be useful to environmental scientists who need to locate water wells that could be affected by environmental problems, such as chemical spills or underground storage tank leaks.

"Groundwater Quality in Kentucky: Arsenic," by R. Stephen Fisher

More than 4,000 measurements of arsenic concentrations in groundwater at 930 sites throughout the Commonwealth were summarized; values were compared in each of the eight major physiographic regions of Kentucky. A map shows sampled sites and concentration ranges. The report will be of interest to citizens who use groundwater for domestic purposes, regulatory agencies, and water-resource planners.

These and other KGS publications are available online at www.uky.edu/KGS/pubs/lop.htm. To order a publication, please contact the Publication Sales office at 859.257.3896 or call toll free at 1.877.778.7827. ❖

KGS mailing list

Would you like to receive the KGS newsletter and announcements of meetings and new publications? If so, we would like to add your name to our electronic mailing list. Please call us at 859.257.5500 or send an e-mail message to **Carol Ruthven** at cruthven@kgs.mm.uky.edu—simply type "Electronic-Mailing List Addition" in the subject line of your message, type your mailing address and phone and fax number in the message—and we will include your name and address in our mailing list.❖

Calendar of events

- **May 16, 2002:** PTTC workshop, "Integrating GPS and GIS for the Petroleum Industry," Lexington, Ky.; contact Brandon Nuttall at 859.257.5500 or by e-mail at bnuttall@kgs.mm.uky.edu
- **June 4, 2002:** PTTC workshop, "Outcrop Analogs for Trenton/Black River Fractured Dolomite Reservoirs," Lexington, Ky.; contact Dave Harris at 859.257.5500 or by e-mail at harris@kgs.mm.uky.edu
- **September 19–21, 2002:** Kentucky Society of Professional Geologists fall field trip; contact Drew Andrews at 859.257.5500 or by e-mail at wandrews@kgs.mm.uky.edu ❖

Awards and grants

Jim Drahovzal received the 2001 Levorsen Memorial Best Paper Award at the Eastern Section meeting of the American Association of Petroleum Geologists, for "Midcontinent Interactive Digital Carbon Atlas and Relational Database (MIDCARB)." Co-authors were Lawrence Wickstrom, Ohio Geological Survey; Timothy Carr, Kansas Geological Survey; John Rupp, Indiana Geological Survey; Beverly Seyler, Illinois State Geological Survey; and Scott White, Kansas Geological Survey. Drahovzal also received this award in 1996.

Steve Greb, Cortland Eble, and **Don Chesnut** received the Coal Geology Division of the Geological Society of America's best paper award for "Spatial and Temporal Trends of Lower and Middle Pennsylvanian Coals, Central Appalachian Basin, U.S.A." at the 2001 national meeting in Boston, Mass.

Dave Harris and **Jim Drahovzal** received funding for a 2-year project to characterize the geology and geochemistry of surface outcrops and new cores of fault-controlled dolomite in central Kentucky. These rocks are direct analogs to natural gas reservoirs in New York. KGS will collaborate with Triana Energy of Charleston, W.Va., to core two shallow boreholes to sample dolomite bodies in central Kentucky. The Ordovician outcrops and cores will provide a unique glimpse of fault-controlled dolomitization, a process that has resulted in the formation of prolific oil and gas reservoirs elsewhere in the Appalachian Basin in Kentucky, Michigan, New York, Ohio, and Ontario, Canada. The New York State Energy Research and Development Authority, Triana Energy, the U.S. Department of Energy, and KGS jointly funded the project. For further information, contact Dave Harris at 859.257.5500 ext. 173 or harris@kgs.mm.uky.edu.❖

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